RESEARCH HIGHLIGHTS

Technical Series 00-127

SLAB-ON-GRADE CONSTRUCTION

Introduction

The use of structural slab-on-grade construction is not common practice in Canada since the depth of frost penetration in most areas, and thus the required depth of footings, warrant the construction of a basement. However, in situations where a basement is undesirable or where problem soils are encountered, a structural slab-on-grade may be preferred.

The usual method of constructing a structural slab-on-grade is to use a thickened slab; at the edges of the slab, where most of the load will be carried, the slab is thickened, the thickened portion being cast integrally with the rest of the slab. A slab-on-grade can also be constructed with grade beams supported on piers, piles or pedestal types of footings. However, this type of construction is generally not used for residential construction.

As structural slab-on-grade construction is not common practice, builders unfamiliar with its use may encounter problems with construction. This project was undertaken to identify common problems with slab-on-grade construction and to provide builders with solutions.

Research Program

A literature review was undertaken to identify common problems with respect to the construction of slab-on-grade foundations. In addition, comments on the problems observed in the field were solicited from inspectors in CMHC regional offices and from residential warranty programs across Canada.

Results

A manual was prepared which addresses common construction problems associated with structural slab-on-grade construction. It does not address issues related to their structural design. The manual follows the format of CMHC's Builder Workshop series, stating various problems, followed by possible causes and solutions. The key points contained in the manual are summarized in the table below:

Problem: Cracking of the slab.

Cause	Solution
Poor construction techniques and practices	Follow good construction practices, including the following: • Dampen the earth before placing concrete. • Avoid over-trowelling. • Do not finish concrete surfaces when bleed water is present. • Keep concrete continuously moist for at least 24 hours. • Never add water on site during placement or finishing. • Maintain concrete above 10°C during and for three days after placement. • Protect fresh concrete from rapid drying, direct sun and wind.

Differential or uneven settlement	Ensure the subgrade is uniform and sufficiently compacted.
Curling of the slab	Minimize the shrinkage of the concrete: • Use the stiffest mix (lowest slump) possible. • Use the largest maximum size aggregate. • Cure the concrete as long as possible. • Reduce moisture loss from the surface by using coatings, sealers and waxes. • Provide sand over dampproofing to allow some moisture loss at the bottom of the slab. • Ensure there are sufficient expansion joints in the slab. • Use a thicker slab.
Inadequate structural strength of concrete	Ensure the slab is properly designed to Part 4 of the National Building Code. Use concrete with sufficient compressive strength, at least 25 MPa, but preferably 30 MPa.
Frost heave	Never pour concrete on a frozen subgrade. Maintain above-freezing temperatures in the house during construction. Use adequate insulation to reduce the depth of frost penetration.
Improper placement of reinforcing and mesh	Use proper installation techniques, including: • Locate mesh no more than 50 mm below the surface of the slab. • Lap mesh at least one square. • Use chairs to support the mesh at the correct height during concrete pouring. • Ensure the minimum concrete cover over reinforcing steel is at least 76 mm. • Lap steel at least 24 bar diameters, but at least 300 mm.

Problem: Damp or wet floor slab, excessive humidity

Cause	Solution
Moisture migration through the slab	Provide a capillary break (for example, a granular layer) under the floor slab. Provide perimeter drainage and/or a sump pump.
Air leakage through the slab	Eliminate cracks and holes in the slab, seal around pipes, drains and ducts, use traps in drains.
Water vapour diffusion through the slab	Dampproof the slab, either on top using at least two mopped-on coats of bitumen where a separate finished floor is provided, or under the slab using at least 0.15 mm polyethylene or Type S roll roofing.
Poor site drainage	Provide good site drainage by sloping the subgrade and all surface grades away from the house and draining downspouts away from the house.

Problem: Cold floors

Cause	Solution
Heat loss from the slab	Provide adequate insulation under and around the perimeter of the slab. Provide radiant heating in the slab.
Thermal bridging	Insulate the edge of the slab.

The manual also provides appendices on two important issues: the preparation of the subgrade and options for insulating the slab-on-grade.

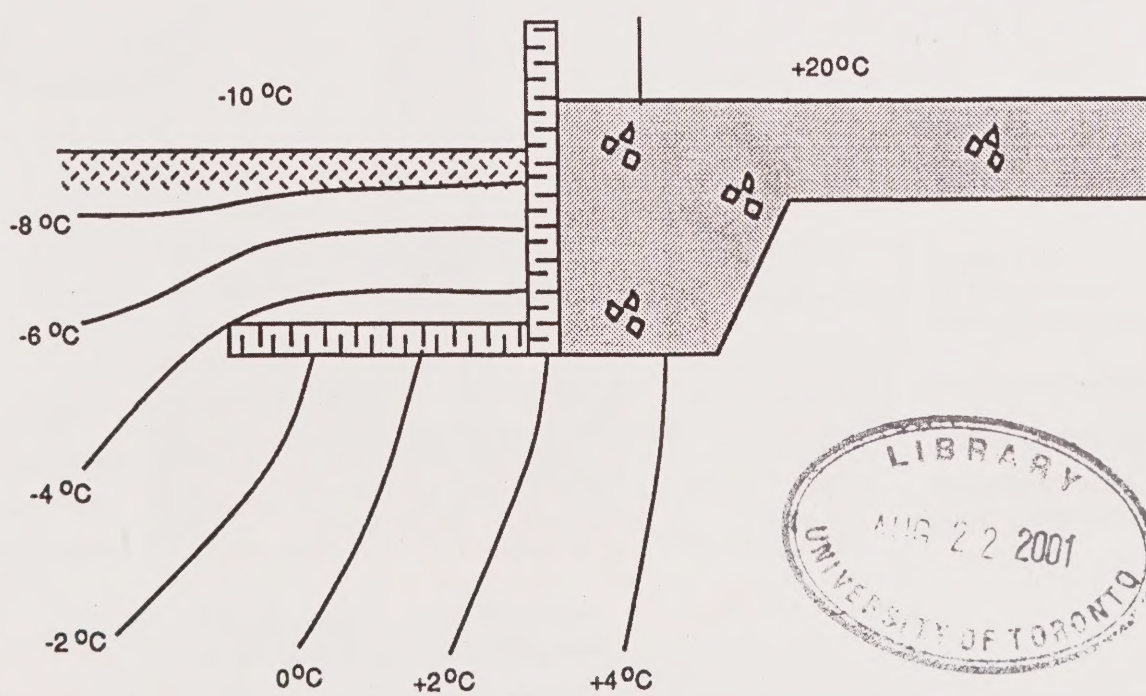
To prepare the subgrade, the topsoil must first be completely removed. The characteristics of the subgrade material must then be evaluated to determine if additional compaction is required to improve the structural properties of the soil. If compaction is required, the limits of compaction should be the entire area of the building plus a 1,500 to 3,000 mm (5 to 10 ft) perimeter border. Testing, using the Proctor test, the Modified AASHTO test or the vibrating hammer test, should be conducted to confirm the compaction of the soil. If fill material is added to improve the subgrade, it should be a stable material that can be thoroughly compacted. Buried utility lines, water pipes, sewers, etc. should be covered with at least 50 mm (2 in.) of compacted soil with similar moisture and density conditions as the adjacent soil.

After the subgrade is compacted to the required density and graded, a subbase layer of 100 mm (4 in.) of well-graded rock or gravel can be spread over the entire subgrade to provide a more uniform support for the slab. It should be compacted to a minimum of 98% maximum density at optimum moisture content. The granular subbase also provides a capillary break helping to dampproof the slab.

The purpose of the insulation system is twofold: to help make the floor slab feel warmer to the occupants and to reduce the depth of frost penetration so that frost heaving is prevented. In slab-on-grade construction, there are two components of slab heat loss. First, since the top of the slab must be elevated from the exterior grade to prevent any wood members from coming into contact with the soil, heat will be lost to the air through the side of the slab. Second, heat will be lost through the soil. Both these components of heat loss have to be considered in designing the insulation system.

A typical insulation system is shown in Figure 1. The vertical insulation is used to prevent heat loss through the side of the slab. The insulation extending horizontally from the edge of the slab forming an insulation skirt is used to reduce the depth of frost penetration. This insulation should be installed in at least two overlapping layers and should be pegged or spot-glued together. The thickness of the insulation at the corners should be increased by 50% over the amount used around the rest of the building and should extend back from the corner by a distance equal to the width of the insulation skirt. The insulation skirt should be slightly sloped to drain water away from the slab, with

Figure 1: A typical insulation system



a cover of 200 to 300 mm (8 to 12 in.) provided on top. The amount of insulation used should be sufficient to prevent frost from reaching the bottom of the footing. As the actual depth of frost penetration is very site dependent, it is recommended that the services of an engineer be retained to determine the amount of insulation required.

In some constuctions, insulation is used under the floor slab to prevent heat loss and reduce energy costs. This practice is not recommended for slab-on-grade construction. The heat loss from the slab into the soil helps to keep the soil warm, reducing the depth of frost penetration. If this heat loss is reduced, the builder runs the risk of frost heave.

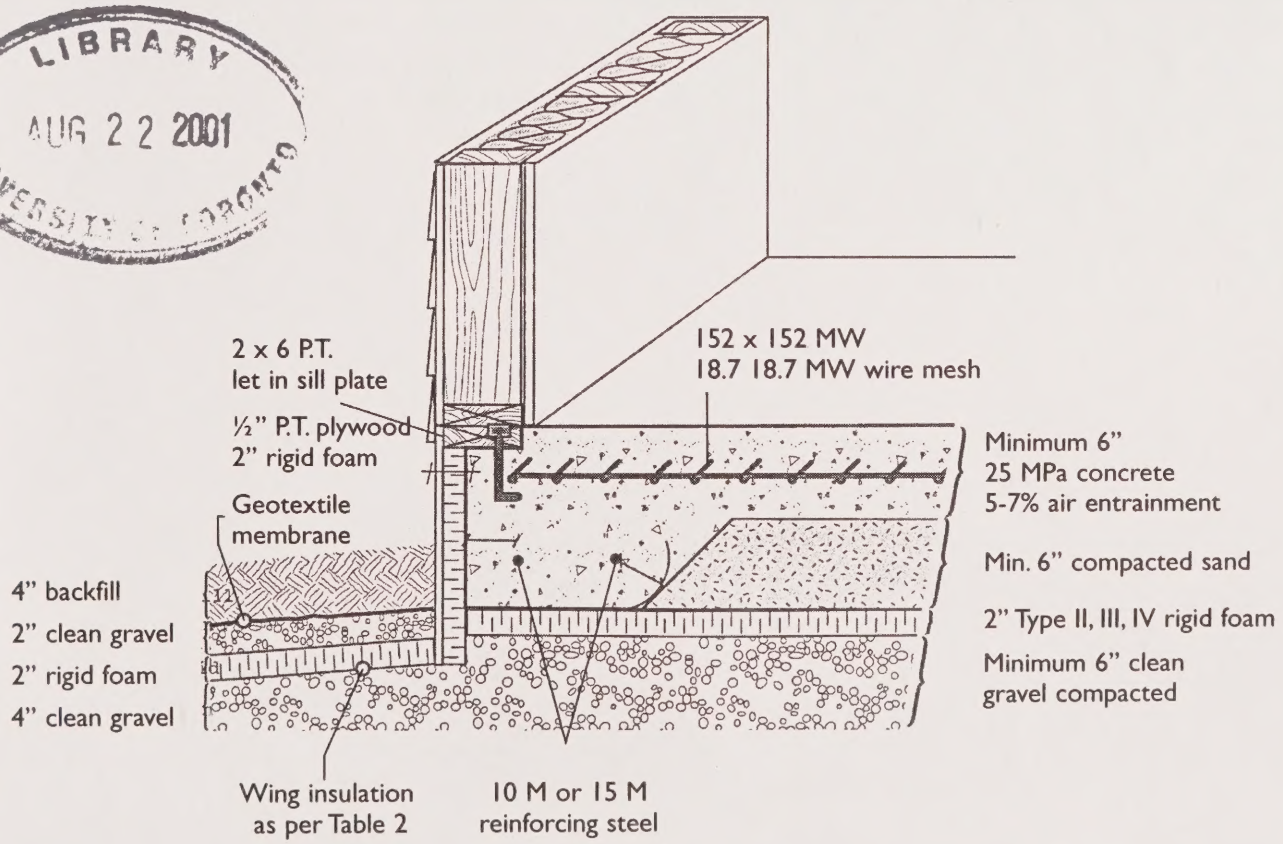
Slab-on-Grade Design Update:

More recent slab-on-grade design information recommends and even calls for insulation underneath the building footprint and beyond (Figure 2). This design detail has been successfully used in Scandanavian countries for many years.

Implications for the Housing Industry

A well-constructed structural slab-on-grade can provide an alternative to basements where a basement is not desirable, such as a senior citizen's residence or a home for physically disabled persons. A structural slab-on-grade can also be used when unstable and problem soils are encountered. This guide addresses some of the common problems that can occur when constructing slab-on-grade foundations and provides builders with means to prevent these problems.

Figure 2: Insulated Slab-on-grade Foundation. Taken from CMHC's *A Design Guide for Rural, Northern and First Nations Housing.*



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